FIELD INVESTIGATION ON REGIONAL SEDIMENT MOVEMENT AROUND THE SHOUNAN COAST

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Regional sand movement and long-term beach deformation were investigated for the fluvial system composed of the Shounan coast and three major rivers flowing into the coast. Anthropogenic impacts, such as dams and weirs, sand dredging, fishery harbors and shore protection structures on long-term beach erosion were discussed on the basis of the comprehensive analysis on nearshore sand volume, mineralogical properties of surface sediments and decadal dating of the sand layer based on Pb-210 radioactivity.

1. Introduction

The Shounan coast, located on the southeastern side of Japan facing the Pacific Ocean, has experienced significant erosion in recent 40 years. The erosion has been influenced by the interruption of longshore sand transport by harbor and coastal structures, and by the shortage in sand supply from three major rivers flowing into the Sagami Bay, that is, the Hayakawa River, the Sakawa River and the Sagami River. It is essential to understand the regional sediment movement in the fluvial system composed of the three rivers and the coast since the sedimentary processes on the Shounan Coast are strongly influenced by the sediment supplies from the three major rivers.

Figure 1 illustrates a map of the watersheds of the three rivers. The sediments supplied from the three rivers are considered to reflect the geology of the individual watershed. The Hayakawa River originates in the Hakone Volcanoes and rushes into the sea with a steep slope. The Sakawa River originates in the Tanzawa Mountains while the Sagami River has a relatively

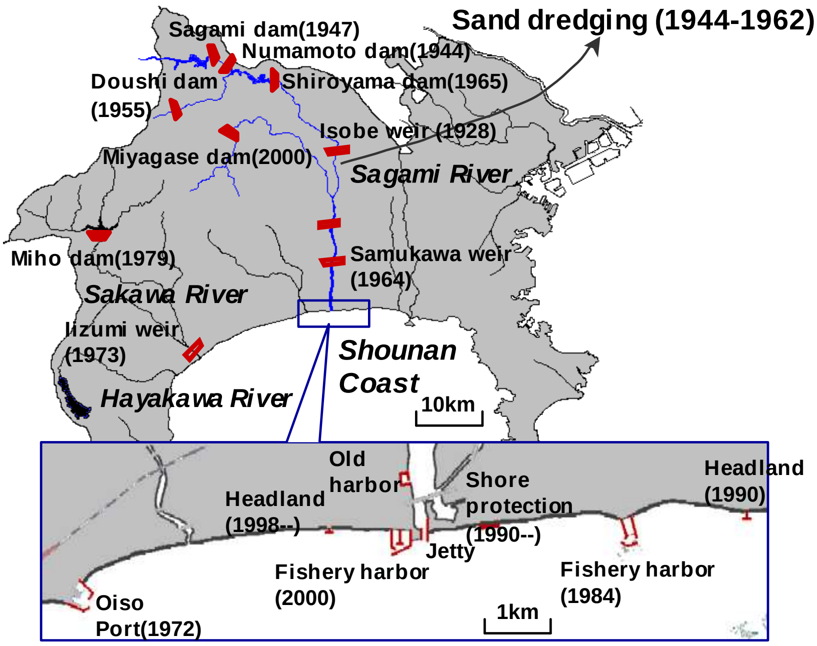

Fig. 1 The Shounan Coast and modern anthropogenic impacts

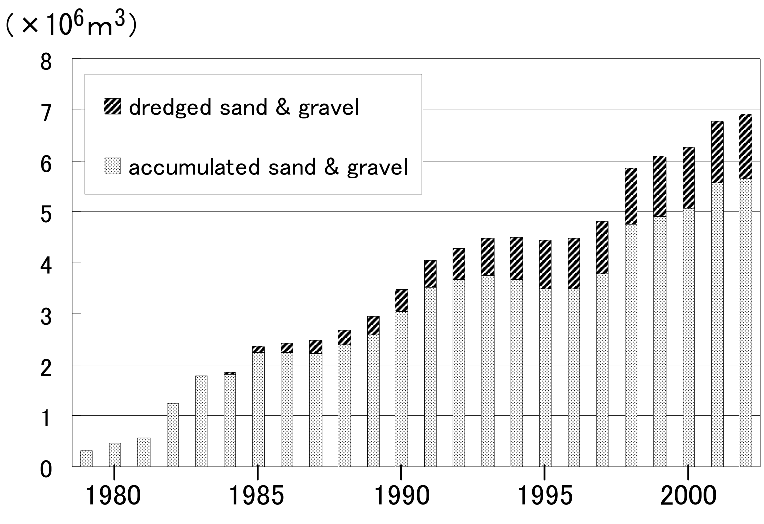

Fig. 2 Accumulation of sand and gravels in the Miho Dam reservoir

large watershed originated in Mt. Fuji. It is noticed in **Fig. 1** that the regional sediment movement has been influenced by various anthropogenic impacts in the last 40 years such as construction of dams and weirs on rivers, sand exploitation from riverbeds and construction of fishery harbors and shore protection facilities on the coast. A comprehensive investigation is considered to be necessary including analyses on quantitative sand budget as well as on sediment quality, such as grain diameter, mineralogical property and historical process of sedimentation.

Figure 2 shows the amount of sediment accretion in the reservoir of the Miho Dam constructed on the Sagami River in 1979. The amount of siltation in the reservoir reached 5.5 million m^3 in 24 years. Considering for the continuous operation of dredging from the reservoir, the average rate of the interruption of sediment by the Miho Dam is estimated at $2.8x10^5$ m^3/year.

2. Spatial and Temporal Change in Nearshore Sand Volume

Quantitative analysis of nearshore sand volume is made on the basis of survey data obtained by the Kanagawa Prefecture with a spacing of 200m. **Figure 3** shows the movement of nearshore contour lines of T.P.0m and T.P.-10m in the region around the Sagami river mouth which is illustrated at the bottom of **Fig. 1**. It is noticed that the contour line has been retreated significantly in the last 30 years especially in the region around the Sagami river mouth. The large retreat in the offshore contour line is partly due to the relatively mild bed slope (1/60) compared with the steeper slope (1/20) at the shoreline.

Figure 4 shows the temporal variation in nearshore sand volume in five sub-regions. The sand volume was estimated in the region from the sea dikes to 1km offshore, and plotted as the difference from that of 1971. The total sand volume decreased significantly during the period from 1970 to 1985. Although it recovered in the period from 1985 to 1995, the total loss of sand in 30 years is estimated at $5x10^5$ m^3. It is also noticed that the main contribution to the loss of sand is found in the region around the river mouth. **Figure 5** shows the cumulative amount of nourishment in this region. It is considered that the recovery of sand volume is partly due to the nourishment.

3. Distribution of Gravel Properties

Surface sediments were sampled at 50 points during the period from June to October 2002. One hundred gravels with diameter from 1cm to 5cm were randomly sampled on the riverbed as well as on the shoreline. The gravels were classified according to the mineralogical property.

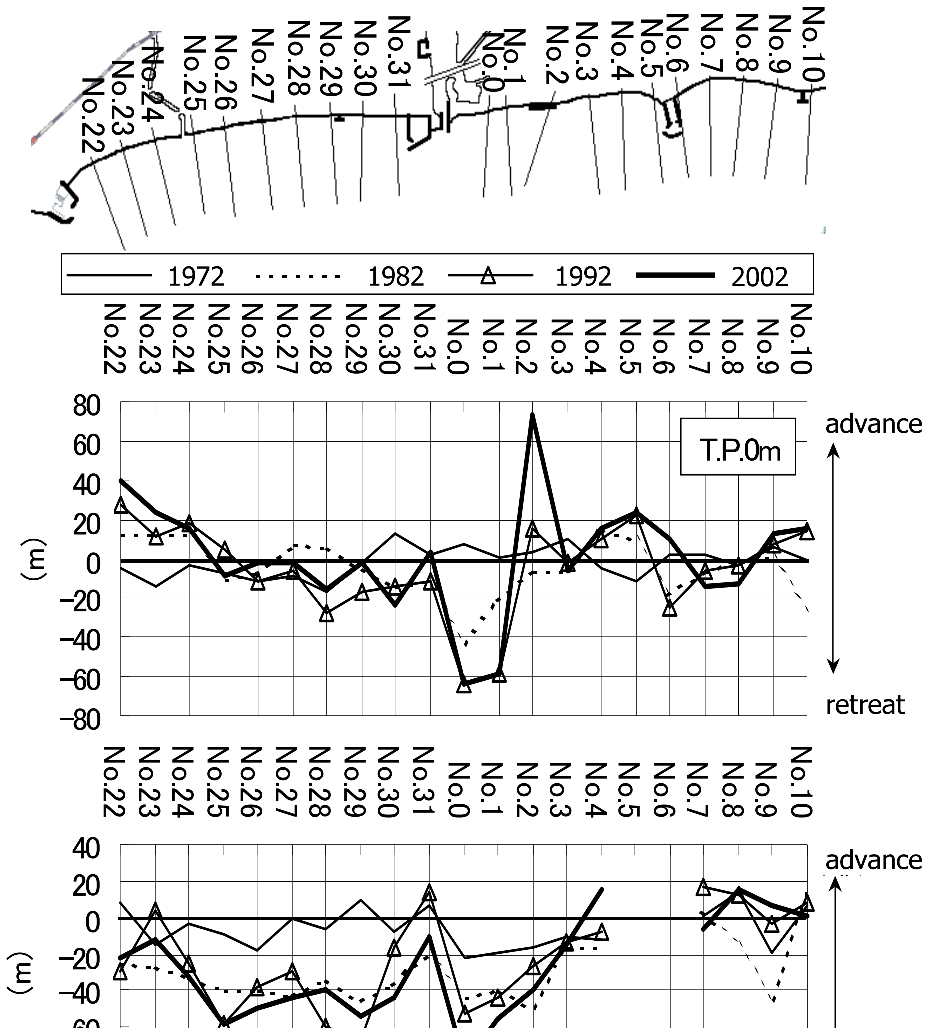

Fig. 3 Variation in nearshore contour lines

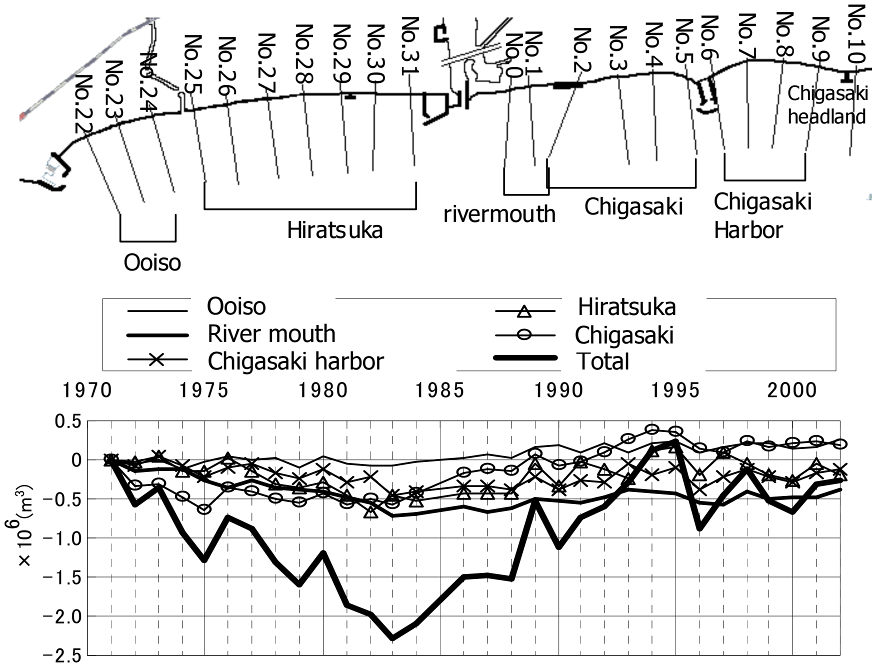

Fig. 4 Temporal variation in sand volume in sub-regions

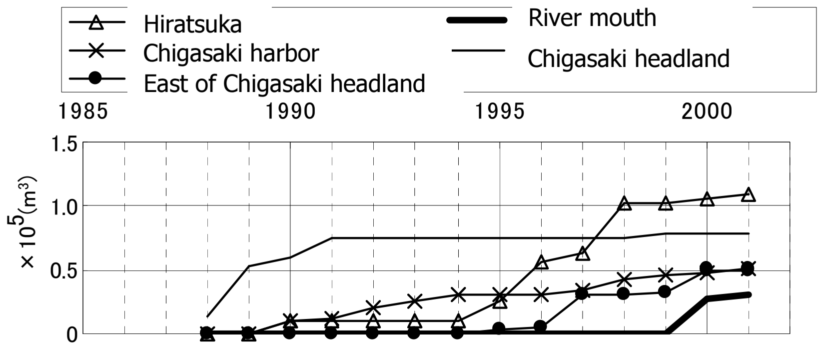

Fig. 5 Cumulative amount of sand nourishment

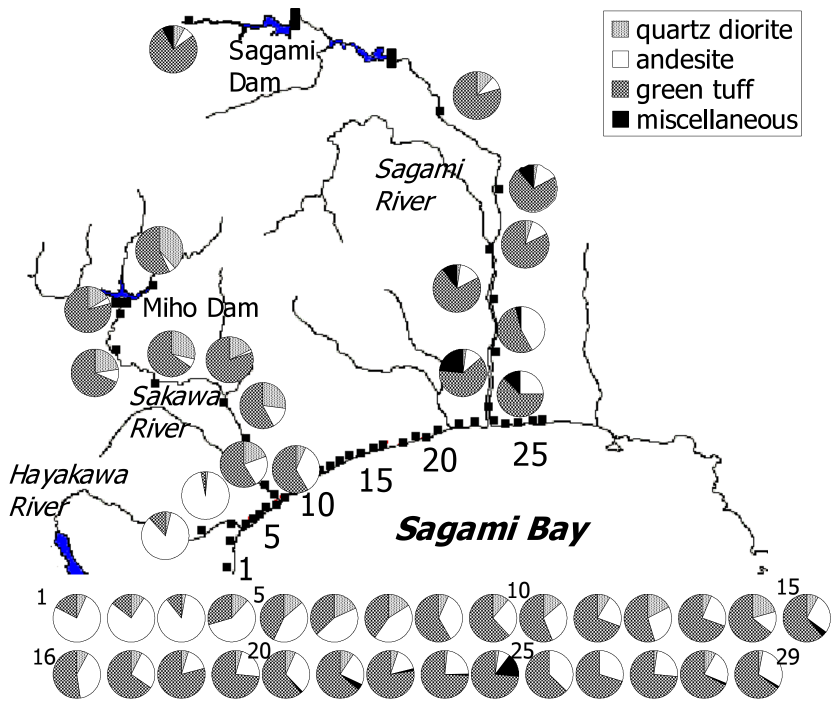

Fig. 6 Distribution of gravel properties in watersheds and coast

Figure 6 illustrates the distribution of mineralogical properties of gravels. The properties in watersheds were plotted at the sampling points and those on the coast are illustrated on the bottom, in the sequence from west to east. It is noticed that characteristic gravels were found in the individual watershed, that is, andesite predominant in the Hayakawa watershed reflecting the geology of the Hakone Volcanoes, quartz diorite and green tuff predominant in the Sakawa watershed representing the Tanzawa Mountains. It is also noticed that the ratio of quartz diorite, a representative rock in the upstream of the Sakawa River, decreases significantly across the Miho Dam.

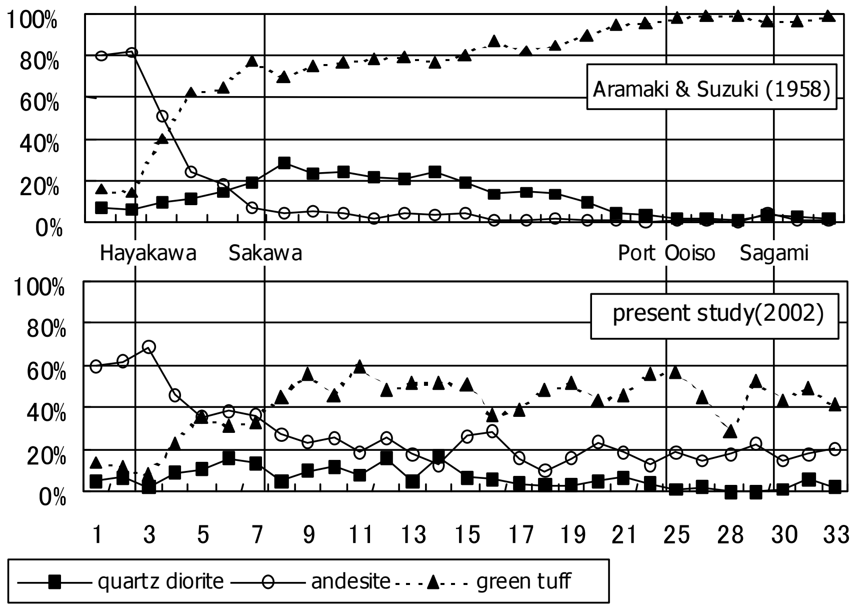

Fig. 7 Change in the distribution of gravel properties along the coast

Figure 7 shows the longshore distribution of gravels. The top figure indicates the measurements by Aramaki and Suzuki (1958) and the bottom is those by the present study. Andesite is predominant near the Hayakawa river mouth and gradually decreases on the eastern coast, indicating the eastward longshore transport. The eastward longshore transport was also confirmed from the gradual decrease in the maximum size of gravels on the shoreline, which changed from 20 to 30 cm at the Hayakawa river mouth to 3 to 4 cm at the Sagami river mouth. Quartz diorite and green tuff, which are representative rocks in the Sakawa River watershed, are predominant near the river mouth of the Sakawa River. However, the ratio of quartz diorite was found to be decreased significantly in the recent 40 years. This is considered to be due to the decrease in the sediment supply from the Sakawa River. The decrease of the sediment supply was partly due to the interruption of sands and gravels at the Miho Dam, which was also confirmed by the sudden decrease of the quartz diorite across the Miho Dam in **Fig. 6**.

4. Sand Bar Decline at the Sagami River mouth

Figure 8 shows the profiles of the riverbed in the downstream of the Sagami River. Overall erosion is noticed in the last 40 years. **Figure 9** shows the size of surface sediment of the riverbed. It is noticed that the surface sediments tend to become finer in 1998 compared with that in 1972.

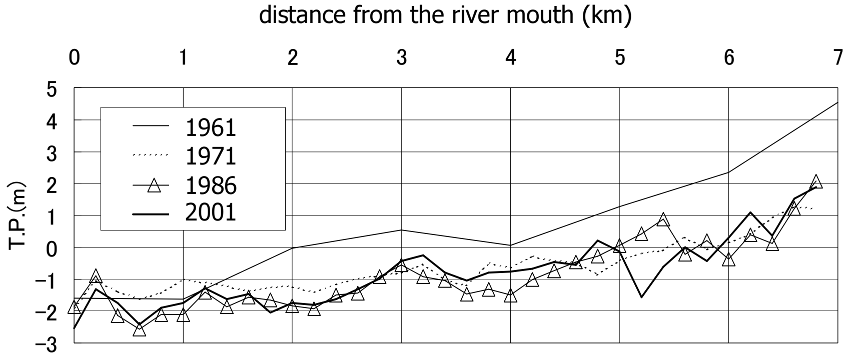

Fig. 8 Change in the riverbed profile in the downstream Sagami River

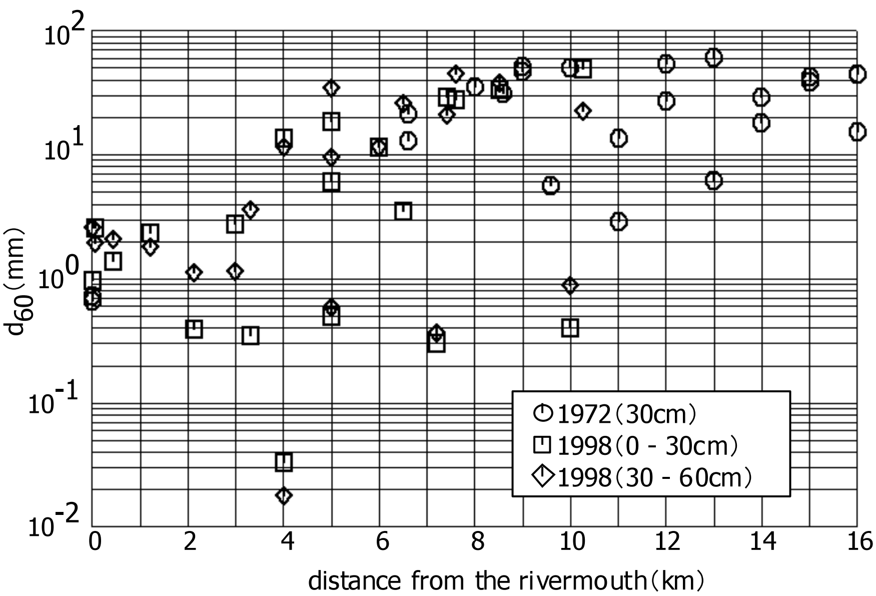

Fig. 9 Distribution of the size of riverbed sediments in the downstream Sagami River

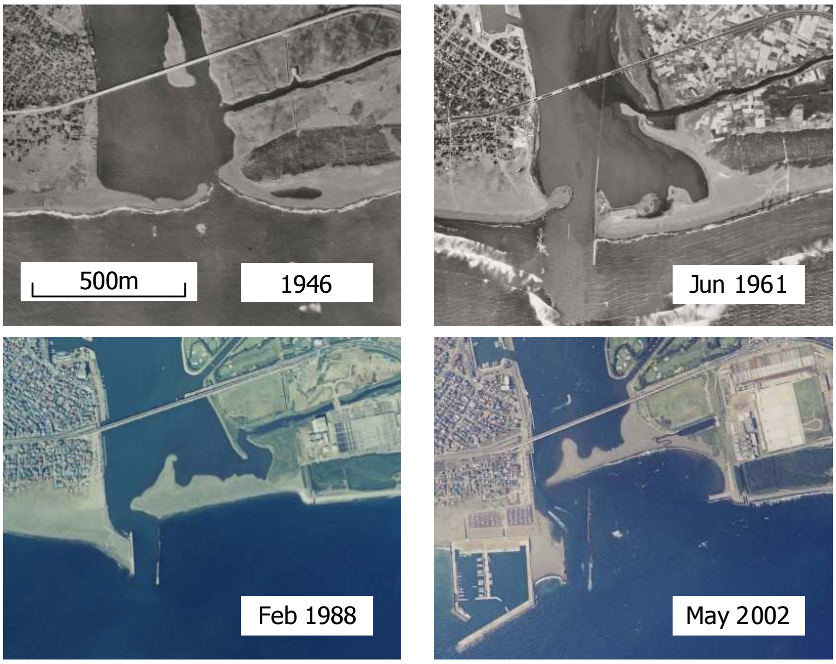

Fig. 10 Topography change around the Sagami river mouth

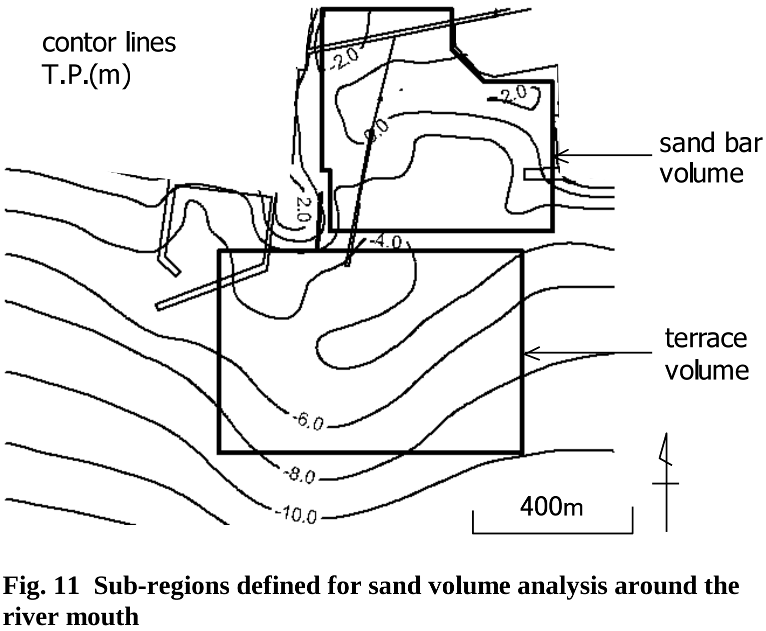

Fig. 11 Sub-regions defined for sand volume analysis around the river mouth

Intensive field measurements were also performed at the river mouth of the Sagami River. The sand bar topography was surveyed in July and October, 2002. The position and the volume of the sand bar were estimated from survey data for recent twenty years. Vertical core samples were taken by using PVC pipes with diameter 4.6cm and length 1.5m.

Figure 10 illustrates the landward movement of the sand bar. The area of the wetland developed behind the sand bar decreased considerably and tended to be lost. Detailed quantitative analysis of sand volume was made by using survey data obtained by the Ministry of Land, Infrastructure and Transport. **Figure 11** shows the area of the survey data. The temporal variation in the shoreline position, the sand bar volume and the terrace volume was estimated and illustrated in **Fig. 12**. The volumes of the sand bar and the terrace were estimated for the region illustrated in **Fig. 11**. The rate of the retreat in the sand bar position is estimated at 5m/yr during the period from 1980 to 1990 and 30m/yr after 1990. The shoreline position at No. 0 line retreated with the same speed until 1990. The shoreline retreat at No. 0 was stopped since it hit the seawall in 1990. The decrease in the volume of the sand bar and the terrace became significant after 1990 and the total amount of sand loss reached 0.1 million m^3 for the sand bar and 0.2 million m^3 for the terrace. The change in the amount and the quality in sand supply from the river, caused by various anthropogenic impacts, is considered to exert essential influence on the sediment dynamics around the river mouth.

The sedimentary processes in the decadal scale were also confirmed by the radioactivity due to Pb-210 fallout flux (half life time 22.3 years). **Figure 13** shows the vertical profiles of radioactivity due to Pb-210 for core samples obtained on the sand bar. It is common for steadily accreted sand layer that the radioactivity of Pb-210 shows an exponential decay. **Figure 13** shows, however, no trend of exponential decay, indicating that the accretion process is not steady. In order to estimate the age of the sand layer, the radioactivity was compared with that of samples taken at the river mouth of the Samegawa River, Fukushima Prefecture (Sato et al., 2004). The radioactivity due to Pb-210 for samples at the Samegawa River was strong near the ground surface and weak at elevation deeper than 1m, showing that the surface sand layer experienced steady accretion in the time scale of the lifetime of Pb-210. The dashed line and the dotted line in **Fig. 13** respectively represent the radioactivity corresponding to the old sand layer and the fresh sand layer sampled at the Samegawa River. It is noticed that the surface sediments on the Sagami river mouth were mostly old sediments in the time scale of 20 years. This is considered to be because of the sediment budget deficit resulted from long-term decrease in the sediment supply from the Sagami River.

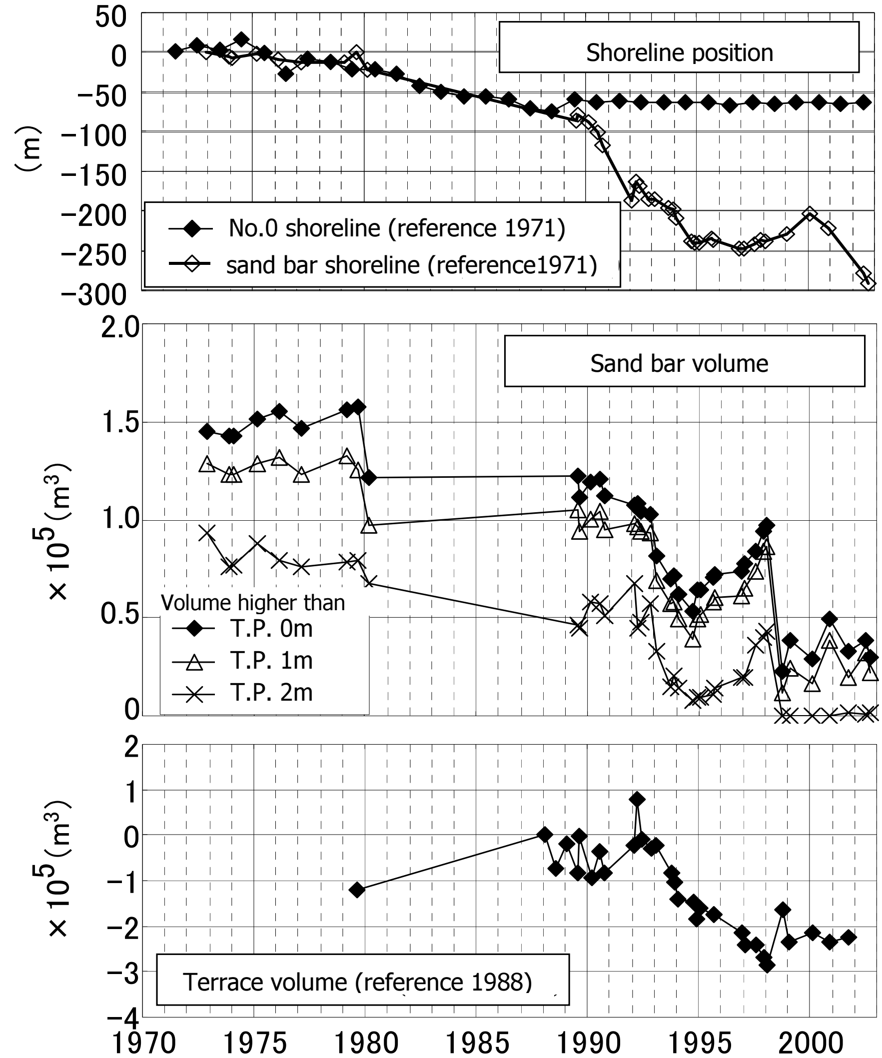

Fig. 12 Temporal variation in the shoreline position, sand bar volume and terrace volume for the Sagami river mouth

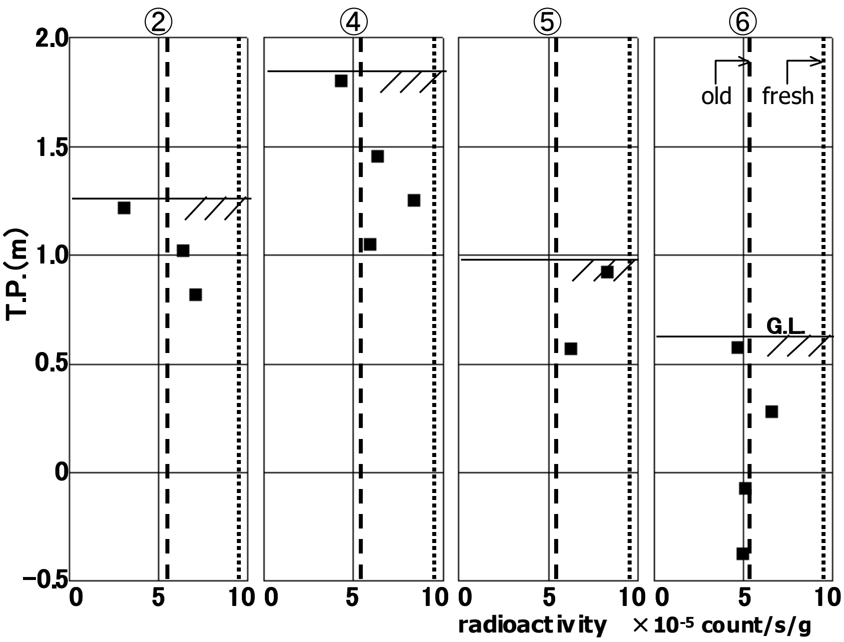

Fig. 13 Vertical profiles of radioactivity due to Pb-210 (46.5 keV)

5. Conclusions

The main conclusions obtained in the present study are summarized as follows:

(1) The prevailing direction of the longshore sand transport on the Shounan Coast is eastward, which was confirmed from the maximum size as well as the mineralogical properties of gravels on the shore.

(2) Distribution of gravels in the Sakawa River watershed suggested the interruption of gravel transport at the Miho Dam. Comparison of the alongshore distribution of gravels with that of 40 year ago revealed significant decrease in sand supply from rivers.

(3) A serious erosion is observed especially at the Sagami river mouth where irreversible processes of landward migration of sand bar, reduction in the sand bar volume as well as in the terrace volume are in progress. The radioactivity measurements of Pb-210 indicated the surface sand layer of the sand bar is relatively old in the decadal timescale.

Acknowledgments

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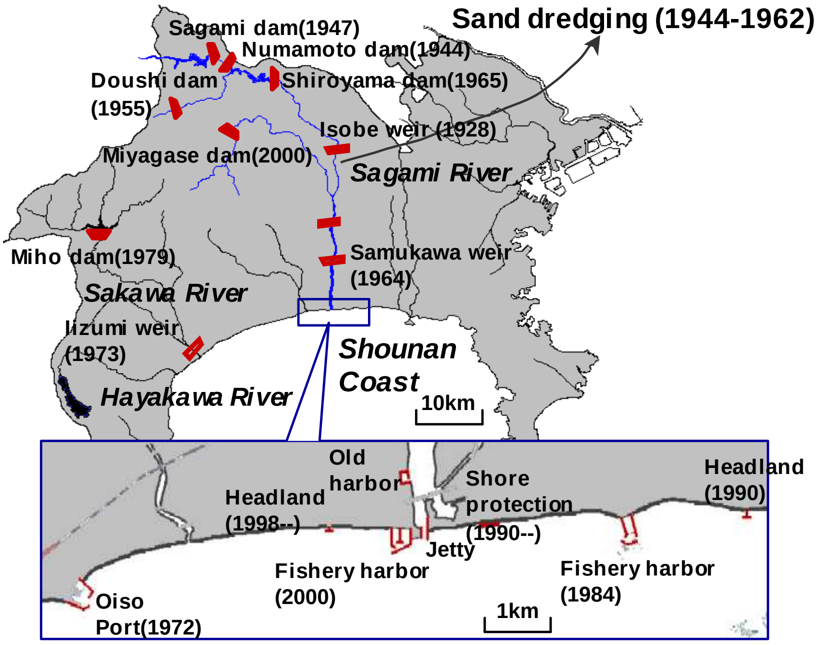

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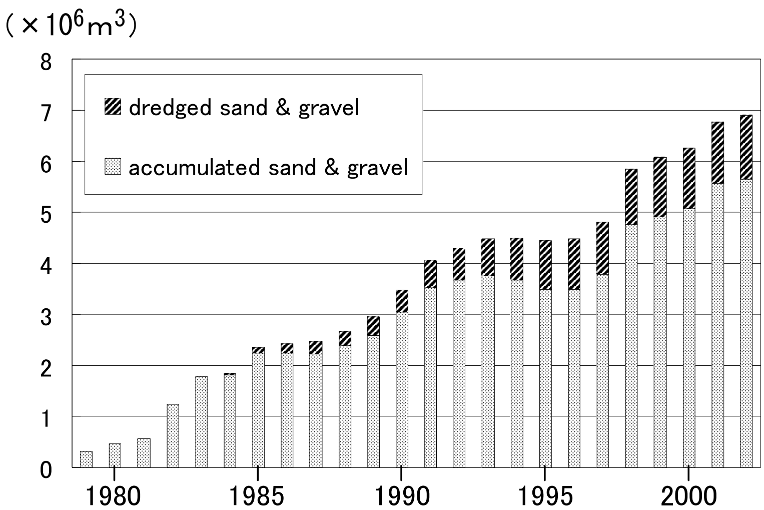

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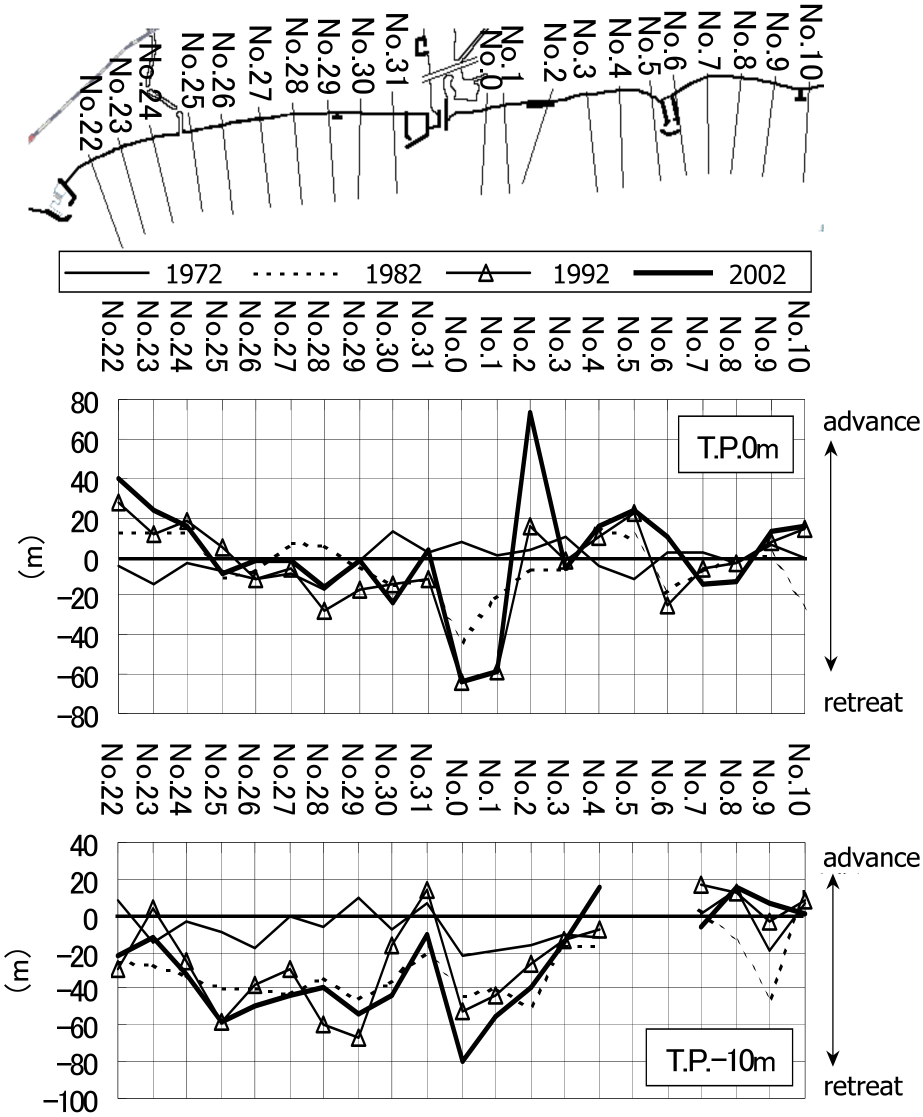

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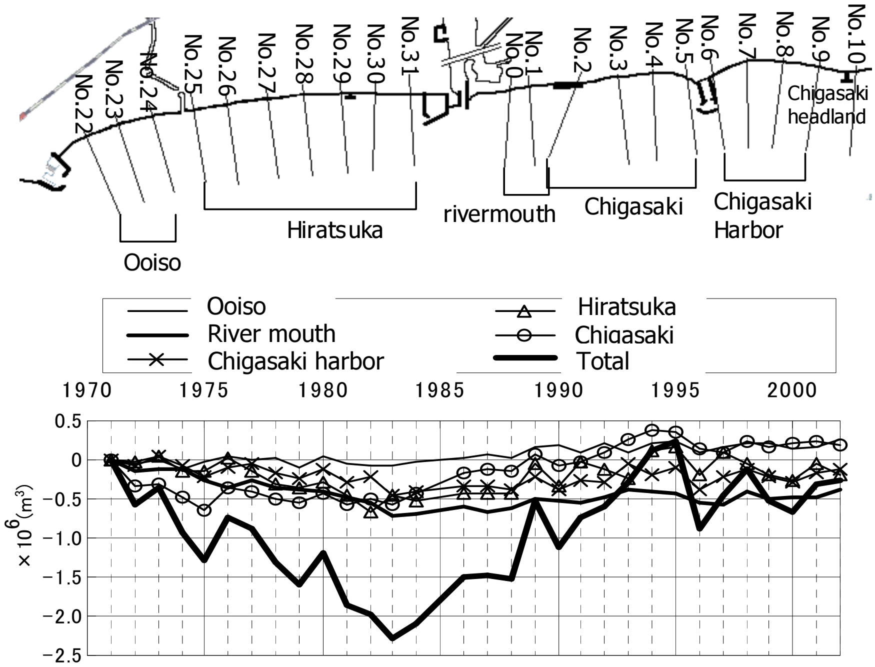

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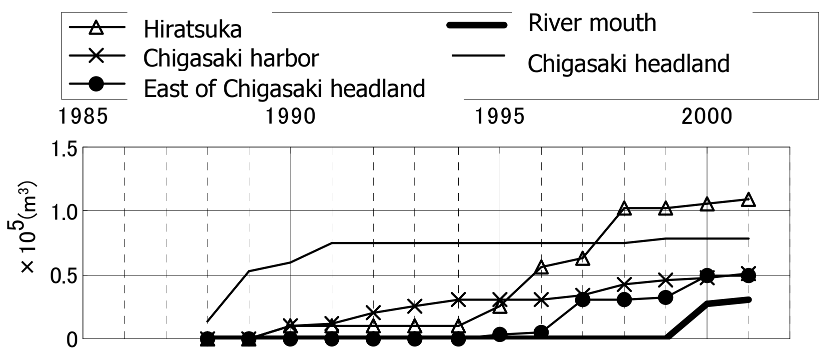

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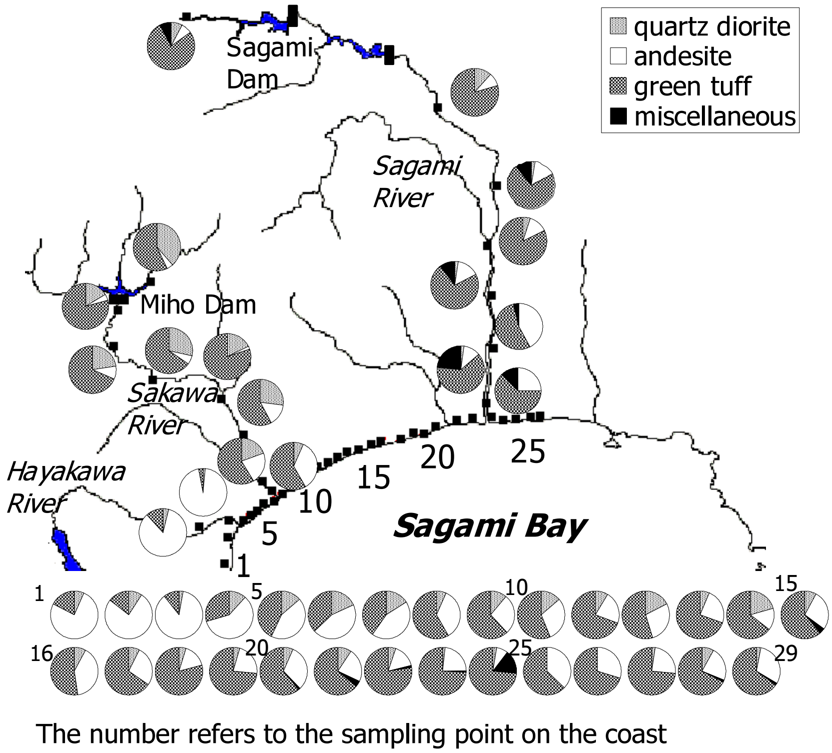

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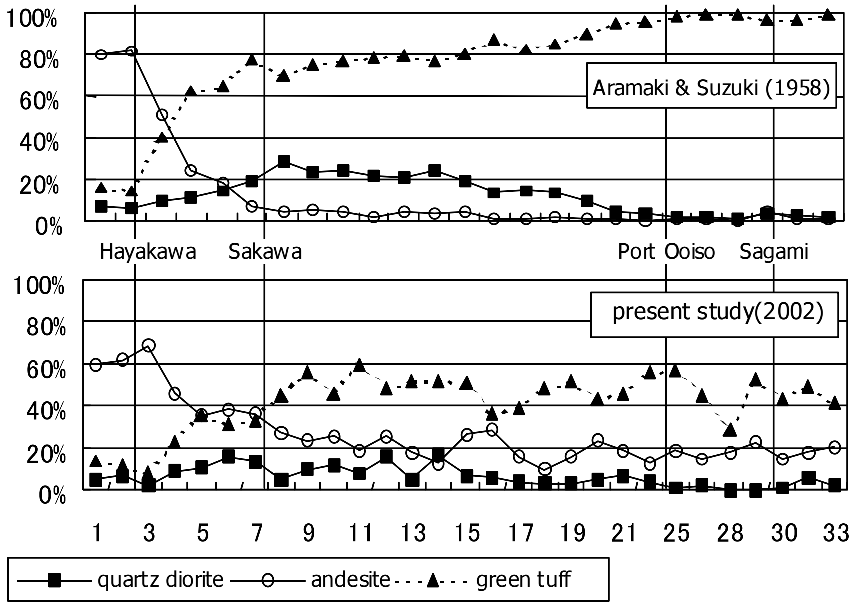

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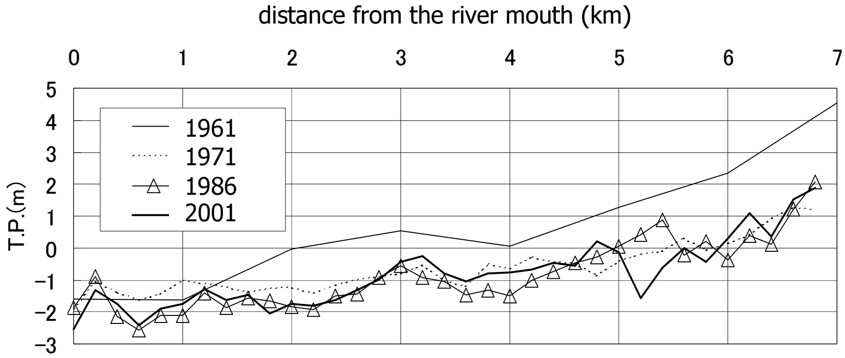

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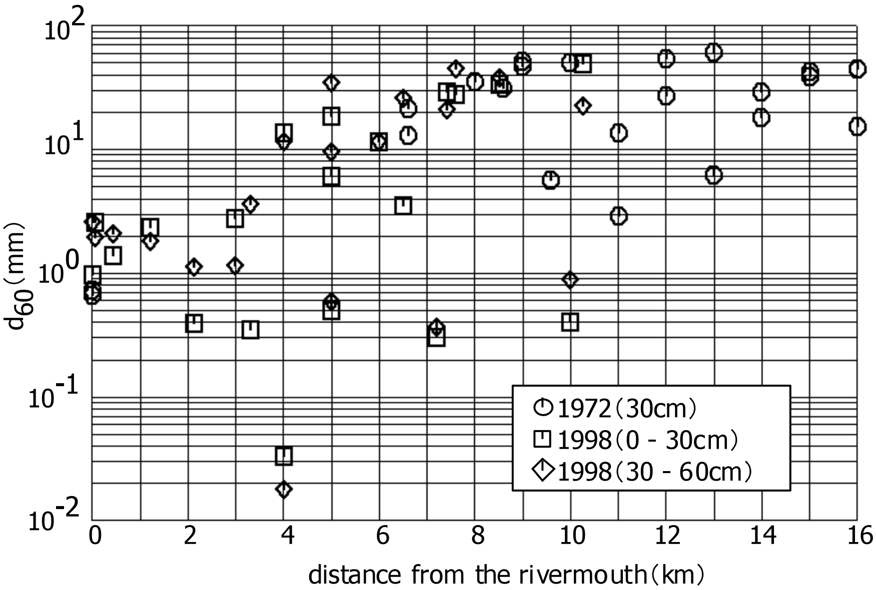

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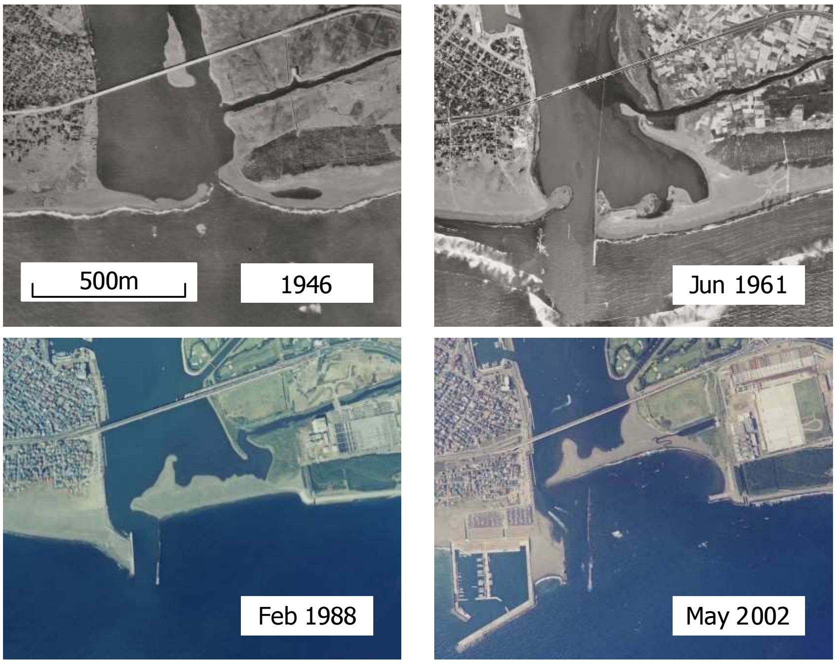

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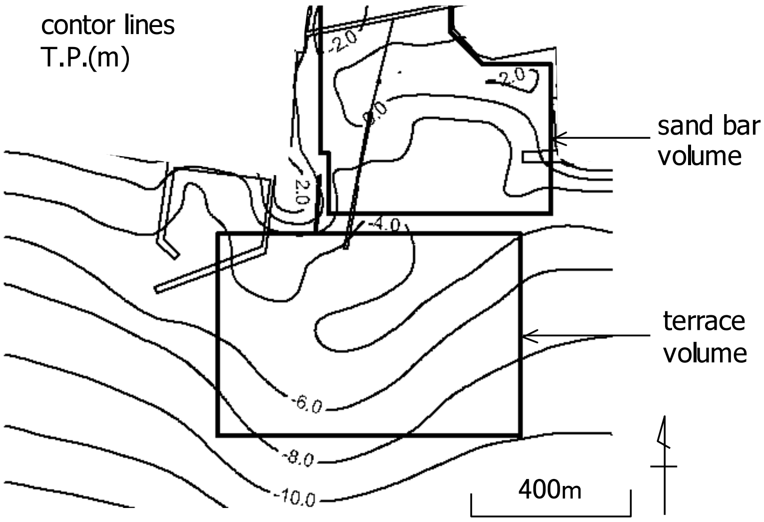

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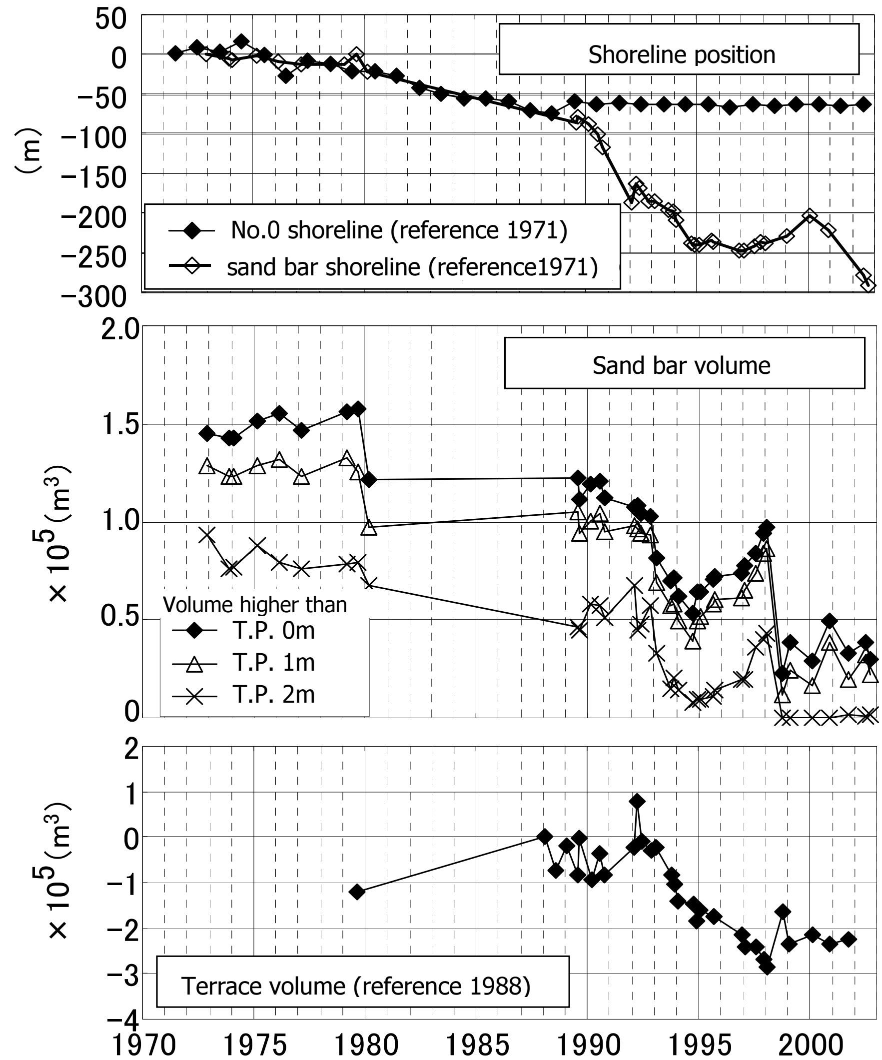

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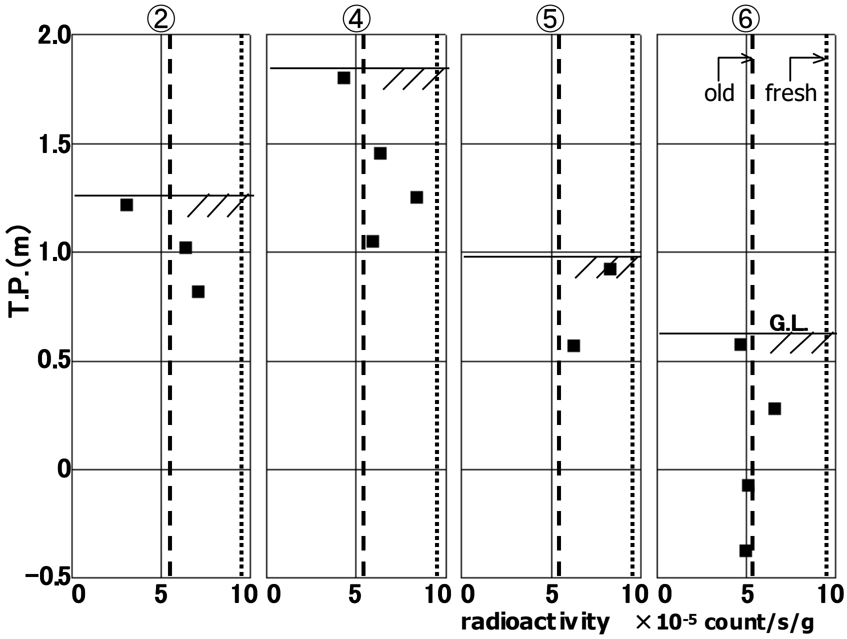

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